I. *A Letter to the Royal Society, from Mr* Anthony Van Leeuwenhock, *F. R. S. concerning* Animalcula *on the Roots of Duck-weed,* &c.

YOu may remember, that in my Letter of the 25th of *Decemb.* 1702. I affirm'd that the Animalcula, repreſented by Fig. 8. a. b. c, that were faſtned to the ſmall Roots of that Green ſtuff found on the top of the Water in our Ditches and little Canals, which we call Duck-weeds, had two ſmall Wheels iſſuing out of their Bodies.

A certain Curious Gentleman, that ſaw the Motion of theſe Wheels with great ſatisfaction, entreated me, that when I had an opportunity, I would once again ſhow him this Wonderful Rotation.

In the Month of *July* laſt, I cauſed ſeveral of theſe Weeds, as they were carried by the Stream thro our Town, be taken out of the Water in an Earthen Pot, and took my full view of the forementіon'd Animalcula at ſeveral times, which appear'd as here in Fig. 1. A B C D E F G. The Caſe or Sheath of which is repreſented by A B G, into which the Animalculum betakes itſelf, upon the leaſt ſhaking or ſtirring of the Duck-weed, and then thruſts itſelf out again as far as B C F G, and at the ſame time appear the two little Wheels deſcribed by C D E F, in obſerving the Motion of which one would be apt to think they were two real Revolving Wheels.

But ſo ſoon as we were able to place the Animalculum before our Eyes, in ſuch a poſition that we could view the little Wheels, not partially, as is here repreſented, but compleatly, and all at once, we were convinced of our

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our Miſtake in our former Aſſertions; for now we ſaw clearly that what appear'd before to be two diſtinct little Wheels, was really one and the ſame Circumvolution.

Now, in order to give you a clearer Notion of the two deſcribed Wheels, I order'd the Painter to draw 'em larger than they appear'd to his ſight.

Fig. 2. HIKLM repreſents the ſaid Wheels, in which the Rotation proceeds from H to I, and ſo on from I to K, and from K to L M.

I have often ſtood in ſuſpence whether this Regular and Wonderful Rotation did really happen as it appeared to me, and ſeveral other Gentlemen that ſaw it; yet I could not chuſe but be ſatisfy'd at laſt of the *Phænomenon*, foraſmuch as having, in order to my entire ſatisfaction, thrown away thoſe Wheels (to the Roots of which the ſaid Animalcula cleaved) and made my Obſervations on ſeveral others, I found the ſame event every time, only with this difference, that the internal Arches in Fig. 2. deſcribed by K and M, were not near ſo much Indented.

During thoſe Obſervations, one Animalculum appear'd to me, as in Fig. 3. N O P Q R S T, and N, that part of it by which it was faſtned to the Weed.

This Animalculum had his Receptacle or little Houſe (repreſented by N O T) compoſed of Round Bubbles, which Figure had not occurr'd to me before.

When this Animalculum had thruſt that part of its Body, from O to P, out of its Caſe or Shell, it produced out of its own Body at the ſame time that Wonderful Wheel-work that conſiſted of four round parts, repreſented in Fig. 3. by P Q R S, three of which were to be ſeen very plain, but the fourth at T was almoſt hid from the ſight.

All this Wheel-work moved from P to Q, and from R to S.

After

After I had nicely obſerved the ſaid Animalculum, I directed the Painter to draw the ſame as well as he could, according to its appearance in Fig. 3.

After ſome little time this Animalculum appear'd in ſuch a poſition that we could compleatly ſee all the four parts, whereupon I order'd my Painter to deſcribe the Rotation with a larger Circumference than it really appear'd, to the end that you may the better underſtand this wonderful and unconceiveable Wheel-work with all its Teeth.

Fig. 4. A B C D E F G H I K L M repreſents that Inſtrument that in Fig. 3. is for the moſt part of it deſcrib'd by P Q R S, in which we ſaw the ſaid Teeth and Wheel-work move from A B C to D, and from D to E F G, and after that manner perform the whole Revolution; and foraſmuch as I had placed the ſaid Delightful Animalculum juſt as it was faſtned to the Root of the Weed in the Water, before my Microſcope, I took that opportunity to communicate a view of it to two ſeveral Gentlemen, who were ſtruck with the greateſt Amazement at the ſight of ſuch an inconceivable Rotation; and at the leaſt ſudden touch of the Animalculum, it preſently drew the Wheel-work into its Body, and then its whole Body into its Caſe or Shell, ſo that we could ſee nothing but a kind of Horn, Fig. 3. N O T, in which it hid itſelf; but it quickly put forth that part of its Body deſcrib'd by O P Q R S T, and then the Rotation or Wheel-work proceeded as before.

Now if any body ſhould be inclin'd to make this Experiment after me, he muſt take care to chooſe out Duck-weeds that have long Roots, for I never obſerv'd any of theſe Animalcula in the ſhort Roots of young Weeds, nor indeed in the great Roots, when once they are covered with a rough Matter, and tending to a Decay, as I have ſeen a great many in the beginning of *Auguſt*; neither ought he to leave off his Enquiry, tho he ſhould meet

meet with ten or twenty Roots that have none of the abovementioned Animalcula in them; for it has happen'd to me that I have examin'd more than five and twenty Roots, without meeting with any of theſe Animalcula on them; as alſo, on the contrary, I have ſometimes found three of 'em upon one Weed.

Moreover, in one of my Glaſſes, in which I had ſhut up a Weed with its Root, there was an Animalculum of the length of the third part of an Inch, and ſomething thicker than the ſmall Root of the Duck-weed, the Body of which was for the moſt part Tranſparent, only there was a Gut or Inteſtin that ran thro' the whole length of the Body, and was wrinkled or ſhrivel'd in ſeveral places; and as it came towards the Head it grew rounder and thicker, which I imagin'd to be the Maw or Stomach. This Gut was full of Meat throughout, which the Animalculum had gather'd either from the Roots, or the excreſcent Particles round about it; and foraſmuch as the upper part of the Head was provided with a long and pointed Horny ſubſtance like a Sturgeon, ſo alſo was the Mouth inwards, and joyn'd to the end of the Belly.

The ſaid Gut being fill'd with Meat was in a continual Motion, which I call a pinching or twitching, in order to the attenuation or protruſion of the Chyle; and if the Guts had not been full of Meat, which hinder'd the Tranſparency thereof, I ſhould have ſeen all the Joynts of the Back-bone.

The third day, after I had ſhut up the Animalculum in my Glaſs, I ſaw a long and ſlender little Worm, that I judged to be a Thouſand times ſmaller than the aforeſaid Animalculum, which had inſinuated, or bor'd Part of it ſelf into the Body of the Animalculum, and, as far as it appear'd to me, the Worm labour'd to get in his whole Body; and the next day in the morning I diſcover'd that it was in a manner quite got in, and at night I could ſee nothing of it but a little bit ſticking out; and then I could

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ſee, that in the place where the Worm had inſinuated itſelf, the Animalculum was partly without any Meat, or Motion, whereas there ſtill remain'd ſome Motion above and below that place : Upon the fifth day after, I ſaw another Worm trying to get into the Body of the Animalculum, upon which it made a great ſtir with its Body, and ſo ſhook off its Enemy ; and preſently after I ſaw no Motion in the Guts, ſo that I concluded that the Death of the Animalculum was approaching ; after which it did abandon the Root of the Duck-weed, and placed itſelf on the ſide of the Glaſs, and a little while after I ſaw it lye dead at the bottom ; from whence I firmly concluded, that the Death of the Animalculum was occaſion'd by the Worm's piercing into its Body, whereupon the Guts were ſo wounded that they were depriv'd off all Motion.

Among ſeveral ſorts of ſmall Animalcula, I obſerv'd Three whoſe Bodies were about as thick as the Hair of ones Head, and Ten times as long.

Theſe Animalcula were ſo Tranſparent, that at firſt I took 'em for nothing but empty Skins ; for one could ſee nothing but an exceeding ſmall part of it about the Head, and the hinder part of the Body that was not Tranſparent ; and that part which I judged to be the Bowels, was a ſmall part of it inclining to a yellowiſh colour ; and they had on the fore part of the Head two (as it were) very crooked Claws, and on the hinder part of the Body ſeveral Tranſparent Hairs.

I obſerv'd theſe Animalcula ſeveral days together, and always ſaw that they moved their Bodies very nimbly in a Serpentine motion, and as it were in an inſtant of time, and ſo removed about from place to place ; and as often as I view'd them, I could never find that they ſat ſtill on the Roots of the Duck-weed, or on the ſides of the Glaſs, but were continually roving about in the Water.

Afterwards, when I lookt upon 'em again, I could not perceive the leaſt Motion in their Bodies, either inward or outward, but obſerved that ſometimes they ſubſided in the Water, and then emerged again, but very leiſurely; which appeared very ſtrange to me, becauſe, as I ſaid juſt now, I could not diſcover the leaſt motion in their Bodies; tho I don't doubt to Aſſert, that there is ſome Motion, be it never ſo ſmall, in a Body, which in the ſpace of 2 or 3 Pulſes ſhall one while ſink to the bottom, and then riſe to the top; for it is impoſſible for us to ſet an inanimate Body in the Water in ſuch a poſition, that it ſhall neither ſink quite down, nor emerge quite up to the ſuperficies; and tho we could find a Body (which yet I think is not to be done) that ſhould be juſt of the ſame weight with Water, it could not keep the place in the Water to which it was firſt aſſign'd; for, according as the Water, into which you put that Body, ſhould encreaſe or diminiſh in Heat, that ſame Water would proportionably take up more or leſs Space; and conſequently the Body, that was ſo placed that it could neither entirely emerge nor ſubſide, if the Water, for example, ſhould become warmer, and ſo take up more room, would immediately ſink to the bottom. In ſhort, we have reaſon to be confounded in our imaginations, when we meet with ſuch Animalcula as I before deſcrib'd.

The only Solution therefore that I can give in this caſe, is, That ſuch an Animalculum has ſome Air in its Body; and that by ſqueezing and contracting of its Body it can emit ſome of the *Materia Subtilis* that is mixt with it, by which it naturally ſubſides; and on the contrary, by dilating its Body again, an equal quantity of the ſame *Materia Subtilis* is let in, and ſo the Animalculum, without ſtirring itſelf, ſhall riſe or ſink.

Now I was the more eaſily induced to ſay what I formerly did about the Animalcula that are faſtned to the Roots of Duck-weed; to wit, that they had two diſtinct revolving Wheels, as they appear'd to others as well as my ſelf ; becauſe I have diſcover'd ſeveral Animalcula that thruſt out two Wheels out of the fore part of the Body as they ſwim, or march on the ſides of the Glaſs ; one of which I caus'd to be deſcrib'd by Fig. 5. V W X.

This ſort of Animalcula I found in great numbers in the Gutter-water in Summer, which had ſtagnated ſome days in the ſmall Pits or Cavities of the Lead. Theſe Animalcula are gradually leſs and leſs, ſo far that 50 ſmall ones are not ſo large as one great one, or full grown Animalculum, that was big with young.

In *Octob.* 1702. I cauſed the Filth or Dirt of the Gutters (when there was no Water there, and the Dirt was quite dry) to be gathered together, and took about a Tea-cupful of the ſame, and put it into a Paper upon my Desk ; ſince which time I have often taken a little thereof and pour'd upon it boyl'd Water after it had ſtood till it was cold, to the end that I might obviate any objection that ſhould be made, as if there were living Creatures in that Water.

Theſe Animalcula when the Water runs off them, or dries away, contract their Bodies into a Globular or Oval Figure.

After that the abovemention'd Dry ſubſtance had lain near 21 months in the Paper, I put into a Glaſs Tube of an inch Diameter the remainder of what I had by me, and pour'd upon it boyl'd Rain Water, after it was almoſt cold, and then immediately view'd the ſmalleſt parts of it, particularly that which ſubſided leiſurely to the bottom, and obſerv'd a great many round Particles, moſt of which were reddiſh, and they were certainly Animalcula ; and ſome hours after I diſcover'd a few that had open'd or unfolded their Bodies, ſwimming thro' the Water, and a great many others that had not unfolded themſelves were ſunk to the bottom, ſome of which had little holes in their Bodies ; from whence I concluded that the little

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Creature call'd the Mite had been in the Paper, and prey'd upon the aforeſaid Animalcula.

The next day I ſaw three particular Animalcula ſwimming through the Water, the ſmalleſt of which was 100 times ſmaller than the aboveſaid Animalcula

Now ought we not to be aſtoniſh'd to find that theſe ſmall Inſects can lye 21 Months dry, and yet live, and as ſoon as ever they are put into Water fall a ſwimming, or faſtning the hinder parts of their Bodies to the Glaſs, and then produce their Wheels, as in Fig. 5. W X, juſt as if they had never wanted Water.

In the month of *Septemb.* I put a great many of the laſt mention'd Animalcula into a wide Glaſs Tube, which placed themſelves on the ſides of the Glaſs preſently, whereupon I pour'd the Water out, and then obſerv'd that ſeveral Animalcula, to the number of 18 or 19, lay by one another in the ſpace of a Courſe Sand; all which, when there remain'd no more Water, clos'd up themſelves in a globular figure.

Some of the Bodies of theſe Animalcula were ſo ſtrongly dry'd up, that one could ſee the wrinkles in them, and they were of a Reddiſh Colour; a few others were ſo Tranſparent, that if you held them up between your Eye and the Light, you might move your Fingers behind 'em, and ſee the Motion thro their Bodies.

After that theſe Animalcula had lain thus dry'd up a day or two, I invited ſome Gentlemen to come and partake of the agreeable Spectacle with me; that is, to ſee how the ſaid Animalcula would diveſt themſelves of their Globular figure, and ſwim about in the Water.

According to which, after my Friends had ſatisfy'd their Curioſity, in viewing the Animalcula in their oval or globular form, ſome of which were ſo Pellucid as if they had been little Glaſs Balls, I pour'd ſome Water into the Glaſs Tube, whereupon they preſently ſunk to the bottom; and then the Gentlemen took the ſaid Tube into their Hands, and viewing it one after the other thro a Microſcope, they ſaw the Animalcula after the ſpace of about half an hour beginning to open and extend their Bodies, and getting clear of the Glaſs, to ſwim about the Water, excepting only two of the largeſt of them, that ſtay'd longer on the ſides of the Glaſs, before they ſtretcht out their Bodies, and ſwam away.

When I was by my ſelf, I view'd theſe Animalcula with a Microſcope, after I had pour'd the Water from 'em, in order to ſee how they brought their Bodies into that Orbicular form as is mention'd above; and having fixt my Eye upon two of the biggeſt of them, I obſerved that they did ſtretch out their Bodies in the ſpace of a minute ſeveral times to an extraordinary length, and thrice open'd the hinder part of their Bodies, and diſcharg'd ſome Excrements, which, in the little Water that remain'd about them, were diſſolv'd into ſmall Pellets, before they aſſum'd their round figure; and foraſmuch as I imagin'd that the Female Animalcula endeavour'd to diſcharge themſelves alſo of the Burden of their Young, my Obſervations had laſted longer, but my Eyes being tir'd, I adjourn'd 'em to another time.

In the month of *Octob.* of the laſt year, before the Dirt and Filth of my Leaden Gutter was quite dry'd up, I took a handful of it, and laid it on a glaſed Earthen Diſh, in order to preſerve it; for I don't ſuffer ſuch foul ſtuff to lye long in my Gutter, but twice a year cauſe the Lead to be ſcower'd ſo clean that it looks juſt like New.

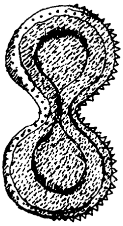
This foul ſtuff being dry is as hard as Clay; ſo that the Mites can't come at the Animalcula, that are thus doubly ſhut up; and now we ſhall ſee whether they will live longer than 21 months.

A few days ago I took ſome of this ſame dry ſtuff, and infus'd it both in cold Water that had been boyl'd, and in Rain Water newly fallen; whereupon the Animalcula

malcula began to ſhow themſelves, and that in great numbers; and ſoon after two ſorts of much ſmaller Animalcula.

In my Letter of the 8th of *Jan.* laſt, I writ to you about the dreadful Storm that had happen'd the 8th of *Decemb.* before; and I told you then that the ſtrong Winds had carried the Waves of the Sea over our Meadows and Orchards, from whence I preſaged a fruitful year, but few people took notice of my predictions; however, having diſcours'd ſeveral perſons, that concern'd themſelves in Tillage or Grazing, upon that ſubject, they all aſſur'd me, that they had never known ſuch a plentiful year for Graſs, as alſo for Peas and Beans, as was the laſt Summer; and among others, I enquir'd of a Gentleman, that does Fatten *Daniſh* Oxen every year, about the ſame: Whoſe anſwer was, That he had a piece of Ground on which he fed 26 Oxen, and that if he had turn'd 26 more into the ſame Paſture, there would have been Graſs enough for them; and that he had never ſeen ſo much Graſs before; and that the Oxen were exceeding fat.

fig: 2.



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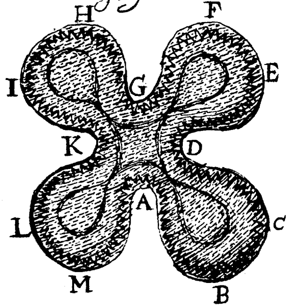

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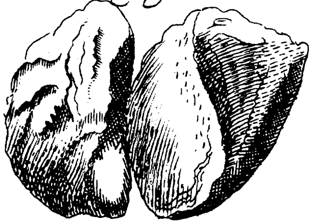

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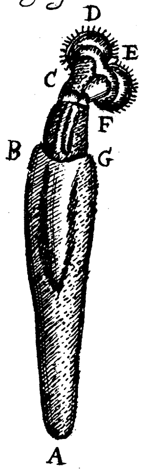

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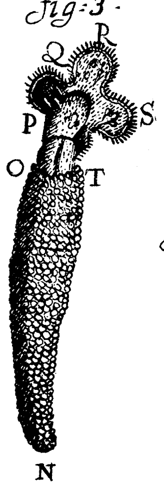

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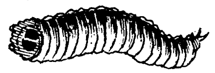

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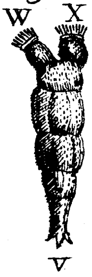

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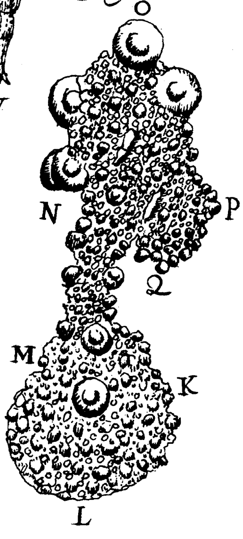

fig: 6.